Demonstrating Innovative River Restoration Technologies: Truckee River, Nevada

Application of the Ecosystem Functions Model (HEC-EFM)

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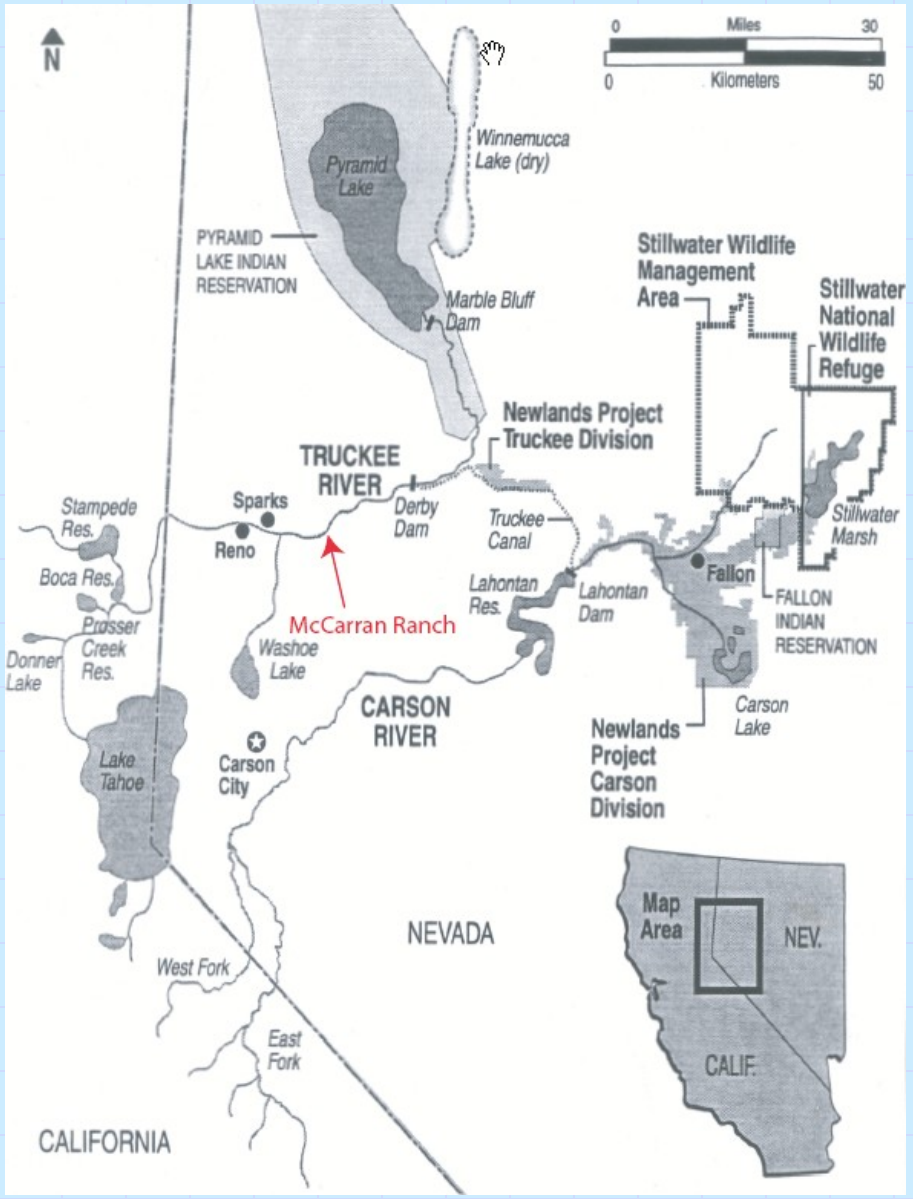
Project Team: Includes members of HEC, DRI, and ERDC

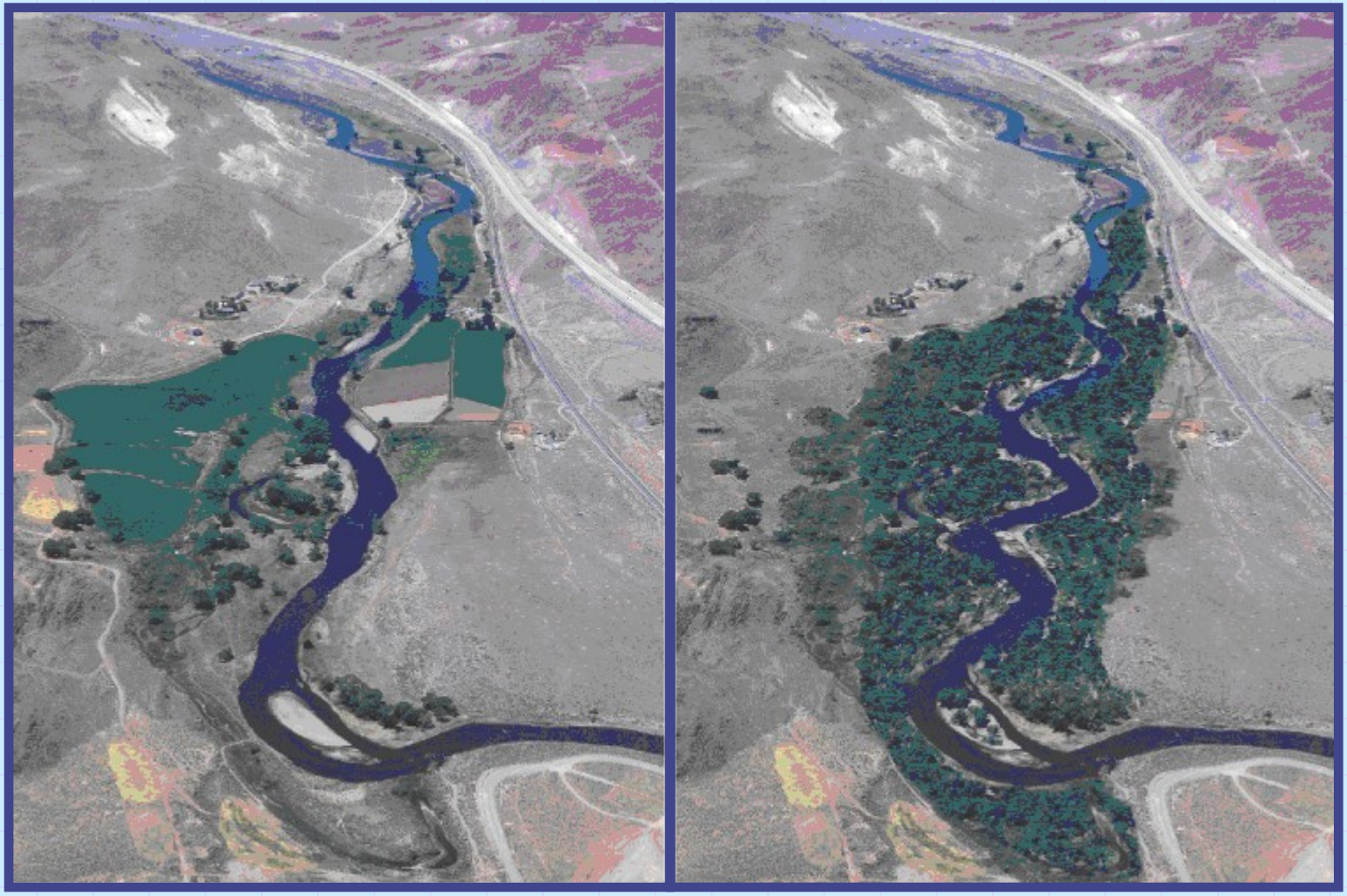
USACE, Hydrologic Engineering Center Desert Research Institute

Project Area

- McCarran Ranch – ~ 5 mi
- Truckee River – ~ 100 mi
- Restore ~ 1 mi. of channel
  - Raise bottom
  - Narrow width from
  - 200 down to 120 ft.
  - Add meanders
- Purpose - Reconnect channel to floodplain



McCarran Ranch/Truckee River Restoration Project



Our Purpose -

- Use and evaluate HEC-EFM to analyze/predict changes to ecosystem habitat caused by modifying channel geometry to more “natural” state
- Process:
  - Apply EFM to identify flows that meet various physical parameters for existing and proposed channel modification
  - Run steady-state HEC-RAS and HEC-GeoRAS to produce floodplain maps of flows identified by EFM
  - Process floodplain maps in GIS to illustrate and quantify the affects of channel modification on various ecosystem habitats.

What is the EFM?

- Planning tool used by biologists, engineers, geomorphologists, and environmental managers to assess how proposed changes to the flow regime (e.g., channel modifications) will impact terrestrial and aquatic habitat
- Uses hydrologic and hydraulic data to help predict eco-response in rivers and adjoining floodplains, wetlands, and estuaries
- Indicates direction and relative magnitude of changes

Input and Data Requirements

What do you need?

- Statistical Assessment only…
  - Hydrologic Data - Period of Record
    - flow time series
    - stage time series
  - Relationships between ecology and hydrology
- …and for Spatial Features
  - Topographic Data (DTM)
  - Geo-Referenced Hydraulic Model
  - GIS Software and Data

EFM Relationships

To be used as indicators of eco-change

- Link characteristics of hydrologic and hydraulic time series (flow and stage) to elements of the ecosystem through combinations of four basic criteria:
  1. Season
  2. Duration
  3. Rate of change (of flow or stage)
  4. Flow Frequency or Flow Duration
- Statistical analyses are performed on the time series records to determine the flow and stage that meet the criteria for each relationship

Truckee EFM Input Data

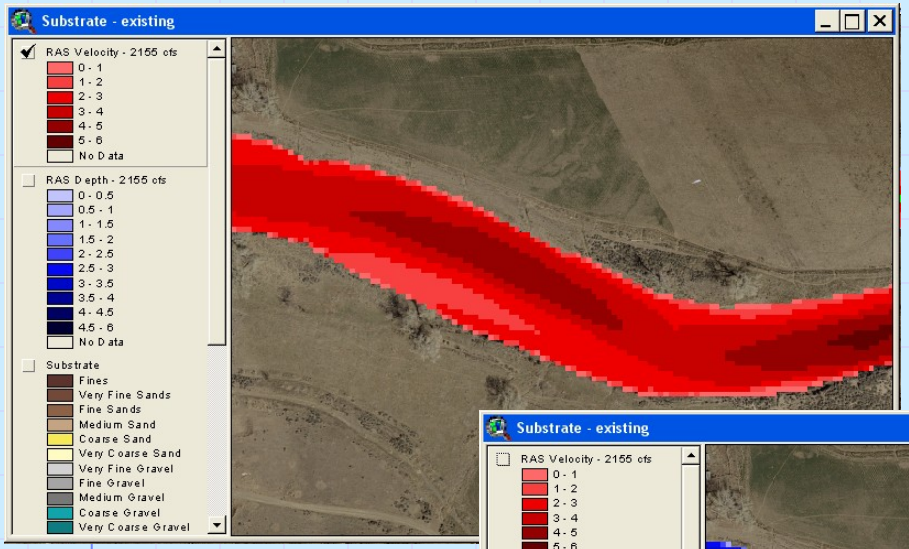
- USGS average daily flows/stages from 1972 to present (below Tracy gage)
- DRI scientists provided ecological expertise for defining relationships
- HEC-RAS model for existing and restored design channel geometry
  - Restored design generated by removing the “existing” stream and adding a set of “restored design” cross sections

Relationships

- Truckee application includes:
  - Cottonwood establishment
  - Cottonwood inundation
  - Substrate
  - Mayfly habitat

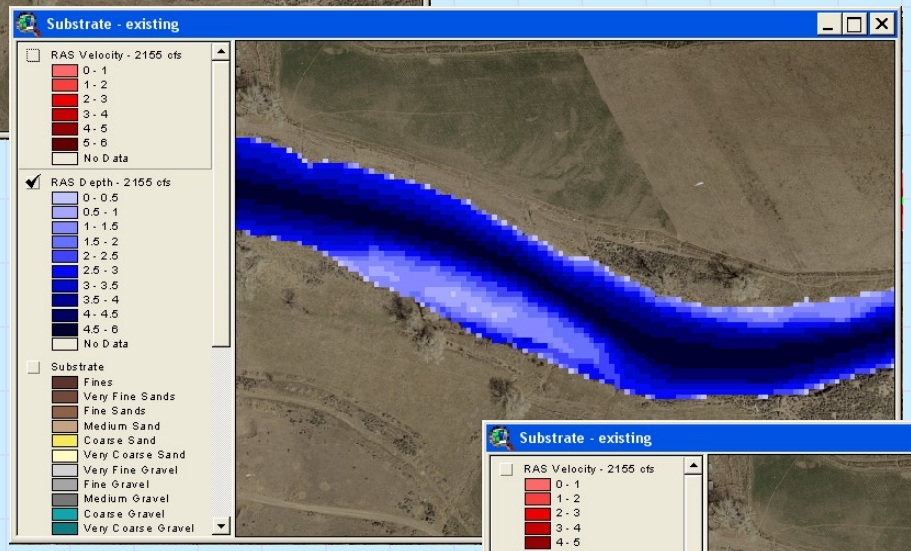
Relationship - Substrate

- Physical Parameter:
  - Channel forming flow
- Ecological Response:
  - Supporting relationship for mayfly analysis
- Relationship(s):
  1) October 1 – September 30 (full year)
  2) 1-day average high flow
  3) for events meeting the above criteria, return period of 2-yr
- Output:
  - Depth and velocity grids for input to Laursen’s equation



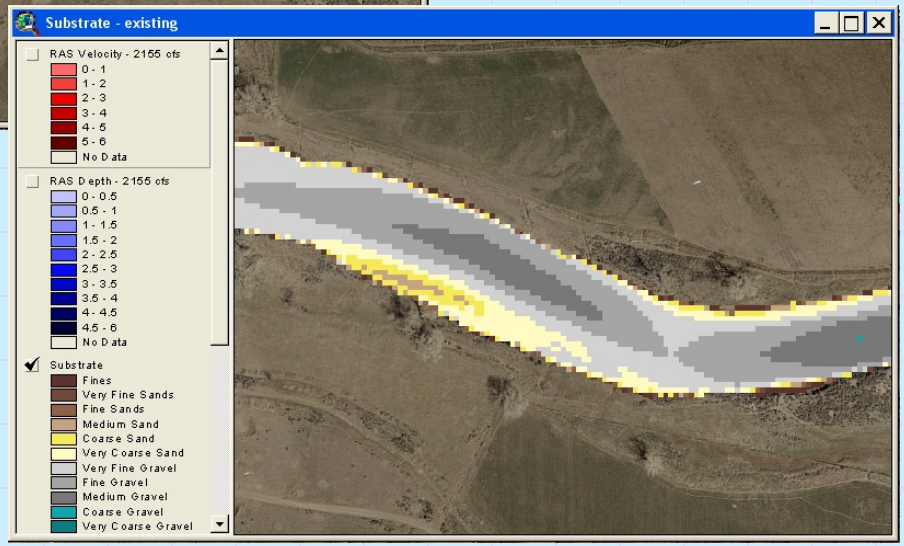
- Substrate
  - Flow = 2,155 cfs

Velocities



Depths

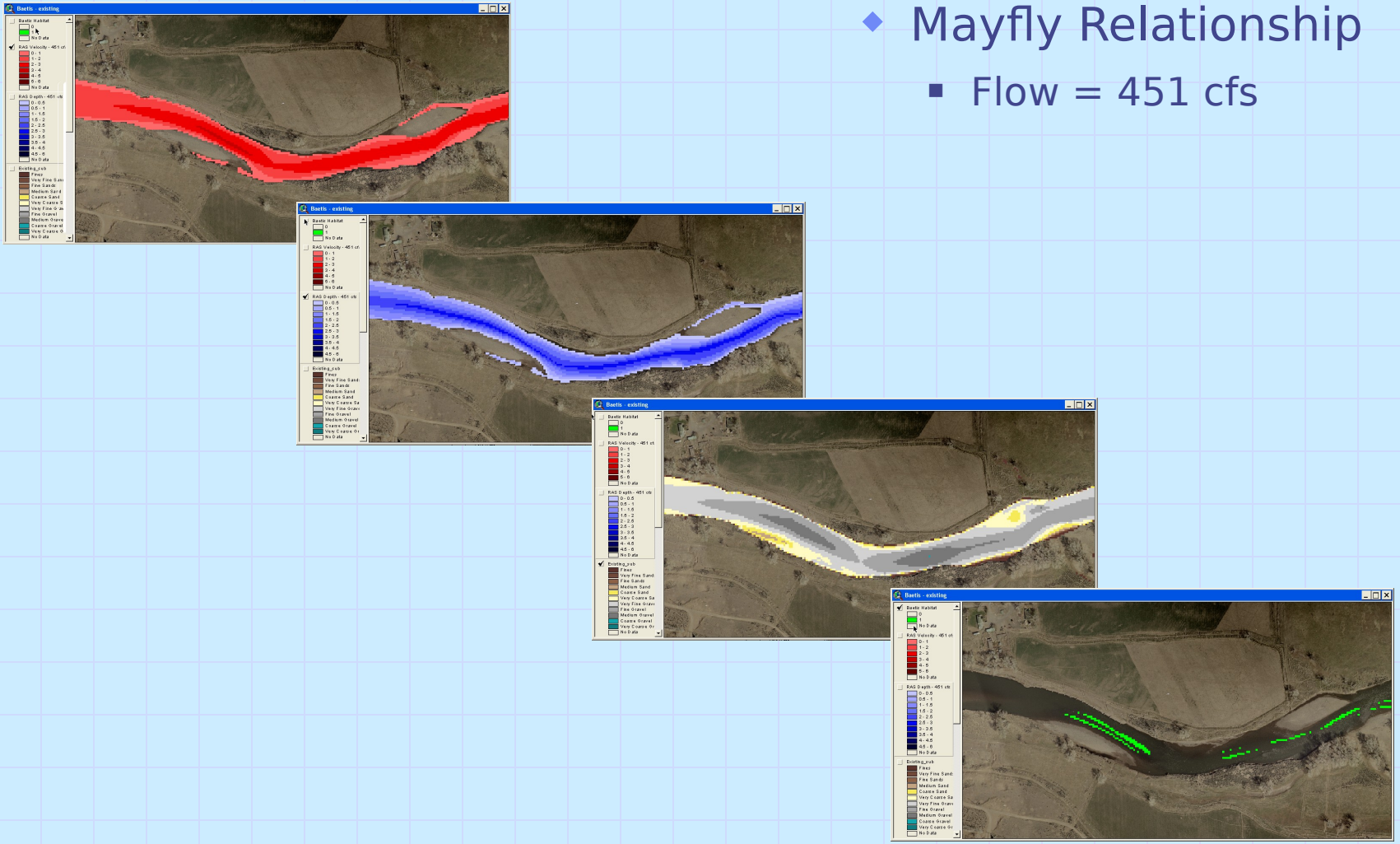
Substrate for the mayfly relationship



Relationship - Mayflies (baetis)

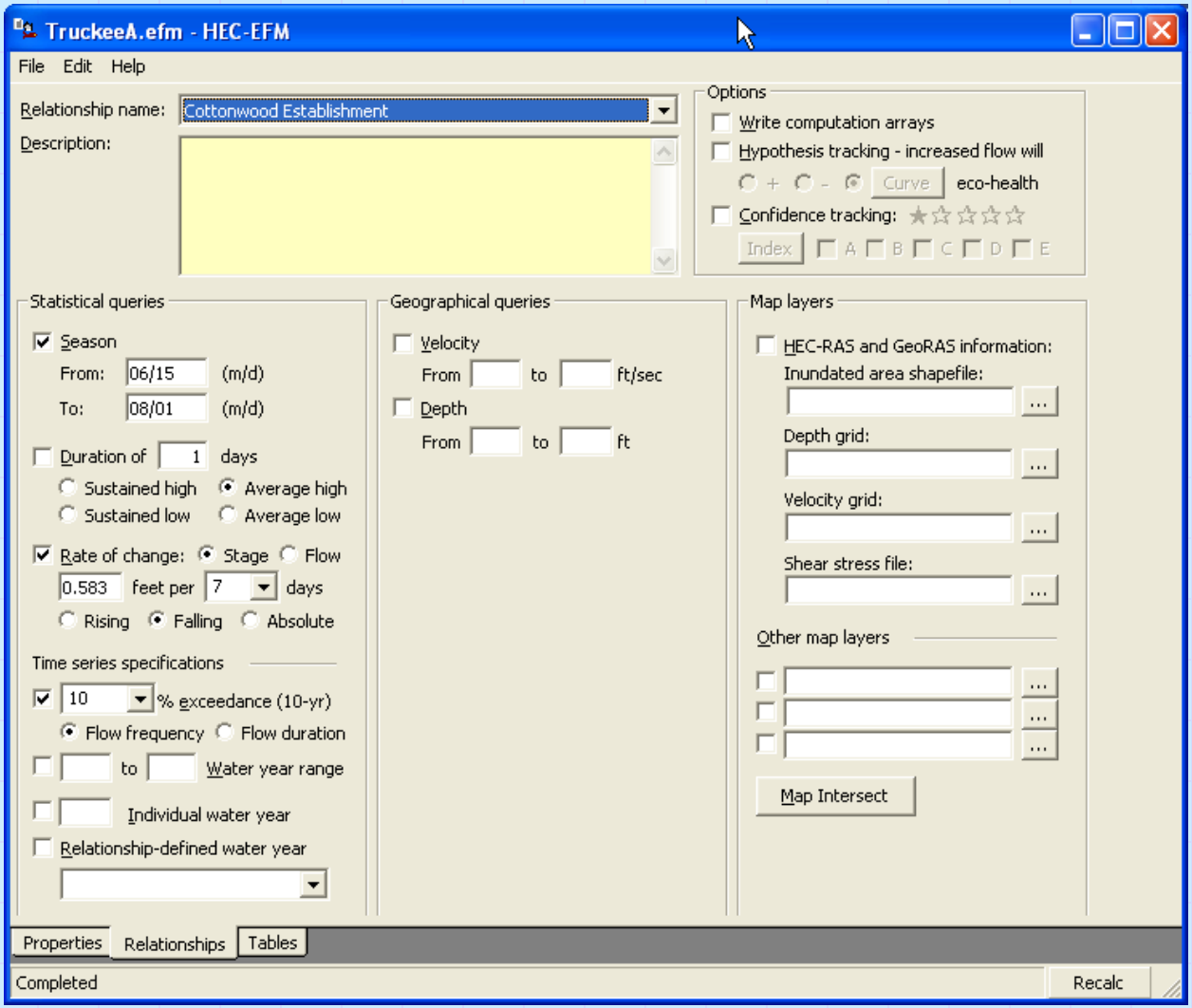
- Physical Parameter:
  - River bed areas that meet suitable depth, velocity, and substrate
- Ecological Response:
  - Happy mayflies (healthy macroinvert populations - good food base)
- Relationship(s):
  1) August 15 – September 15 time period
  2) 1-day average high flow
  3) for events meeting the above criteria, return period of 2-yr
  4) area that meets depth (1.85 - 2.35 ft), velocity (2.5 - 5.0 ft/s), and particle size (0.5 - 4.0 mm) ranges
- Output:
  - GIS layer of mayfly habitat

Criteria Area for Mayflies

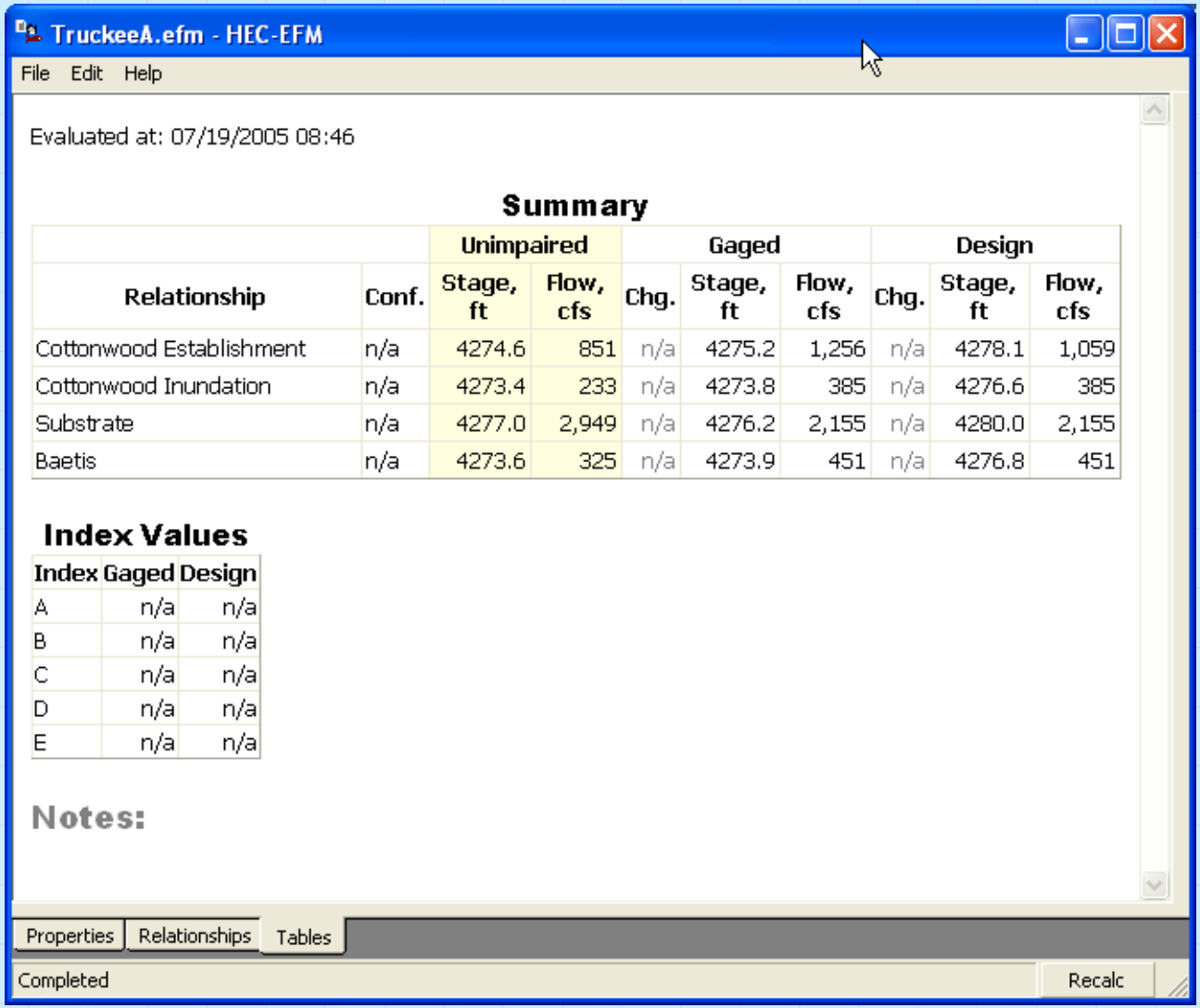


- Mayfly Relationship
  - Flow = 451 cfs

EFM - Graphical User Interface (GUI)



Truckee EFM Application - Statistical Results

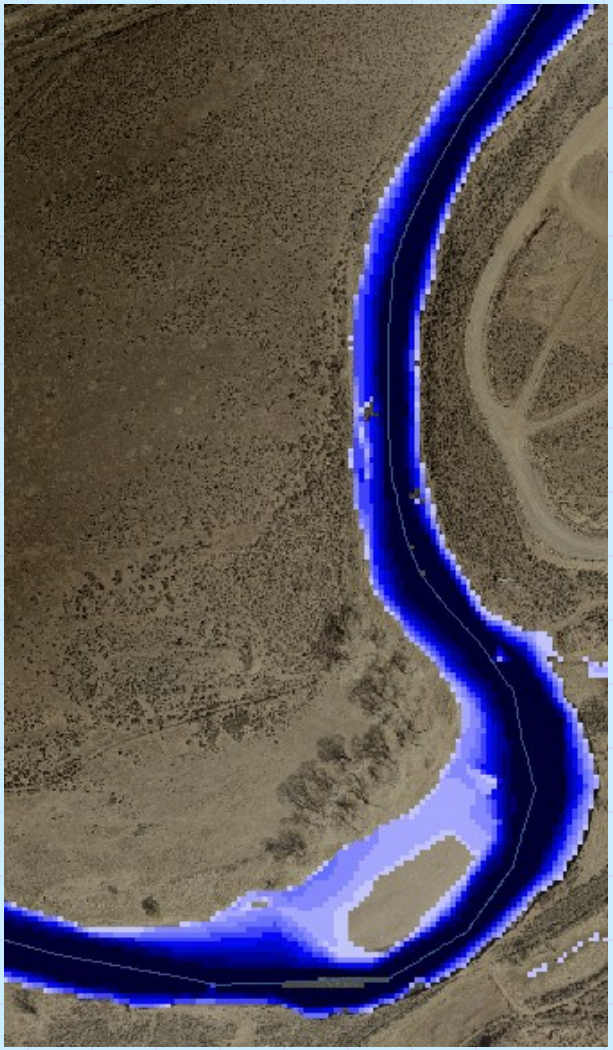


Relationship	Conf.	Unimpaired Stage, ft	Unimpaired Flow, cfs	Unimpaired Chg.	Gaged Stage, ft	Gaged Flow, cfs	Gaged Chg.	Design Stage, ft	Design Flow, cfs
Cottonwood Establishment	n/a	4274.6	851	n/a	4275.2	1,256	n/a	4278.1	1,059
Cottonwood Inundation	n/a	4273.4	233	n/a	4273.8	385	n/a	4276.6	385
Substrate	n/a	4277.0	2,949	n/a	4276.2	2,155	n/a	4280.0	2,155
Baetis	n/a	4273.6	325	n/a	4273.9	451	n/a	4276.8	451

Index	Gaged	Design
A	n/a	n/a
B	n/a	n/a
C	n/a	n/a
D	n/a	n/a
E	n/a	n/a

Spatial Analysis

- Statistical results (flows) are input to a hydraulic model (HEC-RAS) to develop:
  - water surface profiles
  - shear stress
- GeoRAS distributes RAS output into grids for GIS analysis and display
  - depth grid
  - velocity grid
  - inundation boundary maps



Mayflies - Spatial results

Mayfly habitat – Existing condition (5.4 acres)

Mayfly habitat – Restored condition (4.2 acres)

Cottonwood Recruitment - Spatial results

Existing condition
(11.1 acres)

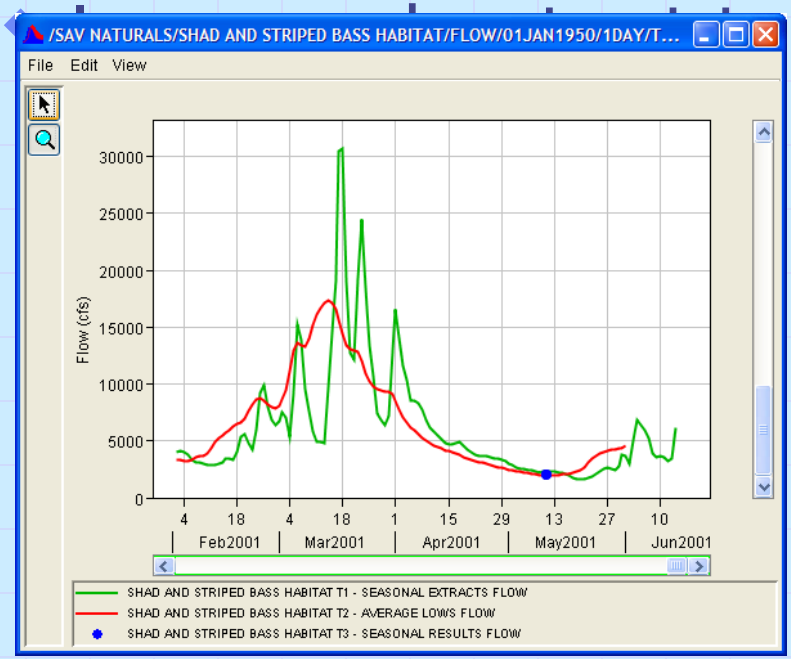
Restored condition
(6.5 acres)

Truckee EFM - Future

- Provided to DRI for ongoing research
- Post McCarran Ranch Restoration
  - Extrapolate method to other parts of the Truckee
  - Integrate with output from a reservoir simulation model to test different water management scenarios

New EFM Features

- Reverse look-ups (specify flow and get %X)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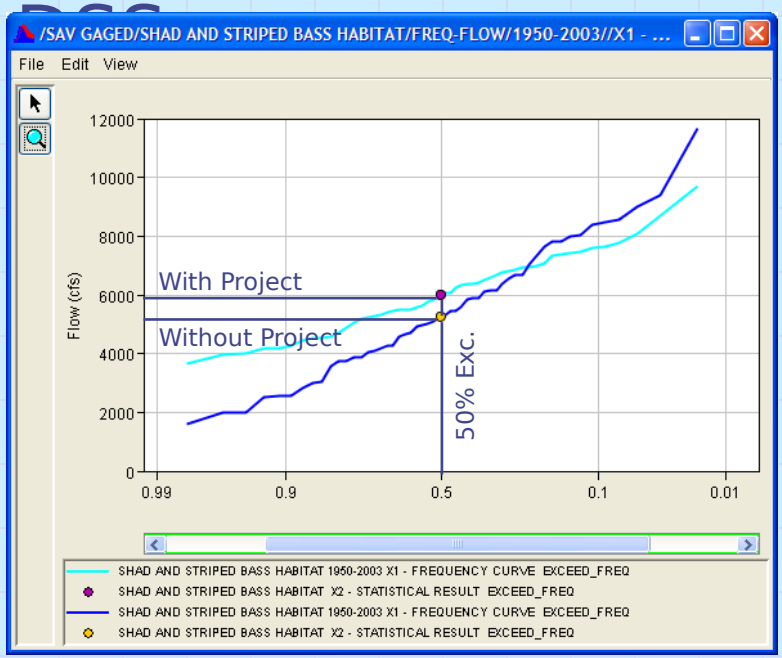
File Edit View
Flow (cfs)
30000
25000
20000
15000
10000
5000
0
4 18 4 18 1 15 29 13 27 10
Feb2001 Mar2001 Apr2001 May2001 Jun2001
SHAD AND STRIPED BASS HABITAT T1 - SEASONAL EXTRACTS FLOW
SHAD AND STRIPED BASS HABITAT T2 - AVERAGE LOWS FLOW
SHAD AND STRIPED BASS HABITAT T3 - SEASONAL RESULTS FLOW


/SAV GAGED/SHAD AND STRIPED BASS HABITAT/FREQ-FLOW/1950-2003//X1 - ...
File Edit View
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
With Project
Without Project
50% Exc.
0.99 0.9 0.5 0.1 0.01
SHAD AND STRIPED BASS HABITAT 1950-2003 X1 - FREQUENCY CURVE EXCEED_FREQ
SHAD AND STRIPED BASS HABITAT X2 - STATISTICAL RESULT EXCEED_FREQ
SHAD AND STRIPED BASS HABITAT 1950-2003 X1 - FREQUENCY CURVE EXCEED_FREQ
SHAD AND STRIPED BASS HABITAT X2 - STATISTICAL RESULT EXCEED_FREQ

New EFM Applications - Bill Williams River

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